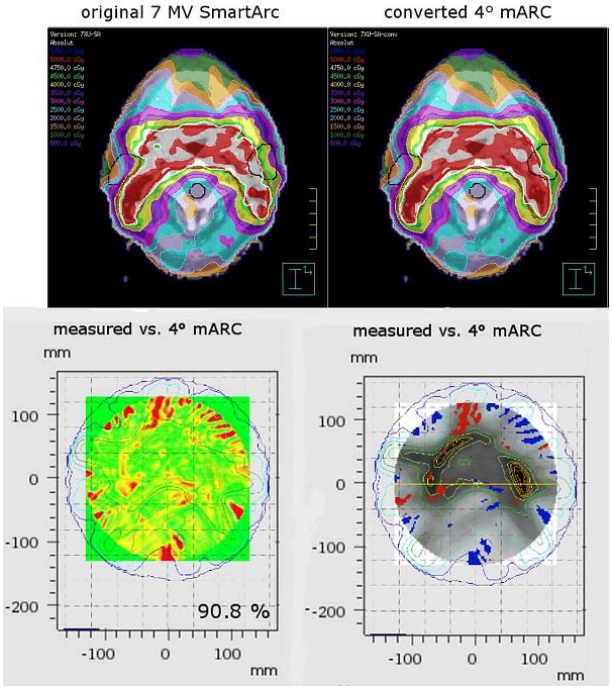
calculated under the assumption of stationary arclet delivery.
The second method is a dedicated solution for mARC planning in Philips Pinnacle (V9.2 or higher) without the detour of an external software. In this approach, a SmartArc (VMAT) plan is created in the TPS with 8° final spacing of optimization points. Then a Pinnacle script is applied which duplicates and shifts the optimization points in such a way to separate phases of beam on and of MLC movement. This resulting plan is still treated like a SmartArc plan in the TPS, but irradiated as mARC at the linac.
We present the proof-of-principle and dosimetric verification using the PTW Octavius rotation unit with 2D-array.

Results: A number of plans were created for prostate and head-and-neck cancer. All converted plans could be irradiated without problems. 3D dose distributions agree with the calculated dose distributions (mARC and approximated stationary field plan) within the gamma criteria for IMRT verification (over 90 % of the points passing the criteria of 3 % deviation in local dose, 3 mm distance to agreement, for all dose values above 10 % of the maximum, example in Figure).



	1st approach: IMRT to mARC	2nd approach: SmartArc to mARC
Starting plan:	**IMRT plan**	**SmartArc plan**
Specifications:	• Beams ordered (either clockwise or counter-clockwise) • Number of segments ≈ number of beams • Collimator angle constant • Same beam energy	• Final spacing of optimization points = 8° (set by script) • Only works in Philips Pinnacle with SmartArc
Workflow:	• Export plan as RTPlan • Run conversion script (linux-based) • correct cross-sum check • import in Mosaiq and send to machine for treatment	• run script in Philips Pinnacle • re-calculate dose distribution • export plan for treatment
User choices:	• if #segments = #beams, this will become an mARC plan • if a beam holds more than 1 segment, this will become a hybrid field • any number of beams with any spacing • any arclet length	• any number of rotations
Limitations:	• generally just one rotation, more rotations require manual separation of beams into several plans	• always creates arclets of 4° length spaced 8° apart
Dosimetric accuracy:	**As good as for a dedicated mARC planning system**	
Treatment stability:	**As good as for a dedicated mARC planning system**	

Conclusion: Both solutions offer the possibility of mARC planning inside a non-dedicated TPS. If Philips Pinnacle with SmartArc is available, plan creation is straightforward and can be performed inside the TPS. Otherwise, a special format of IMRT plan is required, which is externally modified before treatment. In both cases, good dosimetric accuracy is achieved, making this a viable solution for the creation of mARC treatment plans inside any treatment planning system.

EP-1632

Spinal SBRT: improving plan quality using an existing database and a geometric parameter

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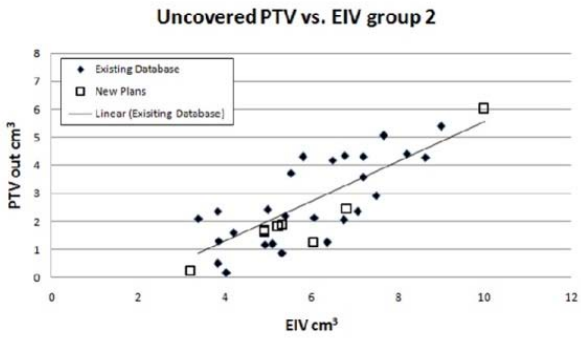
Purpose or Objective: The achievable PTV coverage of spinal SBRT treatment plans depends on the spatial relationship between cord and target. PTV coverage is often sacrificed to fulfill the cord constraints and there are no objective criteria to determine whether an optimal coverage has been achieved. This may lead to suboptimal plan quality and to dependence on the planner's experience. A method to predict the achievable PTV coverage is proposed, which is based on an existing database and on a geometric parameter related to the cord-target 3D distance.

Material and Methods: A clinical database of 70 spine SBRT plans, 41 first treatment and 29 retreatment cases, delivered by the Cyberknife either in 3 fractions or in one fraction is used. TG101 cord constraints or stricter limits for reirradiation were applied. The 3D distance of cord to target was quantified by the expansion-intersection volume (EIV) [M.Descovich (2013)] adapted to spine and calculated as the intersection of the CTV and the cord, both expanded by 5 mm. Plans were classified into 3 groups according to the ratio of the prescribed dose to the cord maximum dose (PD/cordDmax): 1) 1.1-1.65; 2) 1.66-1.9; 3) 1.91-2.9. For each group the correlation between EIV and the PTV coverage was studied, analyzing the linear regression between EIV and the uncovered target volume (PTVout). As validation EIV was calculated for 20 new cases, the expected PTVout value computed by the regression equation and the plans optimized aiming to obtain the predicted coverage respecting the OAR constraints.

Results: EIV values ranged from 0.3 to 18 cc indicating a representative sample of the possible anatomical configurations. Average PTV coverage was 91.2% (range 81.5-98.6%). A significant ($p < 0.01$) positive correlation (Pearson's $r > 0.67$) was observed between EIV and the uncovered PTV (PTVout) over the 3 groups, confirming that for larger EIV, lower coverages are expected. The slope of the 3 respective regression lines increased from 0.67 to 0. 8 for increasing PD/cordDmax. For 16 out of the 20 new plans PTV coverage was higher than the predicted value, i.e PTVout was below the regression line (fig.1) fulfilling the optimization purpose.



Conclusion: This study confirms that EIV is a good parameter to represent the cord-target 3D distance in spinal SBRT. The analysis accounted for the interplay between anatomical characteristics and required dose gradient. The results

obtained by the new optimized plans confirm that the EIV method can guide optimization and improve plan quality.

EP-1633

Optimal dose prescription in Linac-based SBRT using VMAT: a "Pareto fronts" approach

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Purpose or Objective: Pareto fronts are a powerful mathematical strategy to formalize the trade-off between a given set of mutually contradicting objectives. We use this strategy to determine the optimal block margin and prescription isodose for both optimal target coverage and normal tissue sparing for VMAT treatments in extracranial stereotactic radiotherapy.

Material and Methods: Three spherical-shaped targets of different dimensions (20cc, 55cc and 101cc) were selected from our clinical database. GTV included macroscopic disease defined on CT. PTV was defined based on internal margin and setup margin. Healthy liver was considered whole liver minus GTV. A single fraction dose of 26 Gy was prescribed (PD=Prescription Dose). VMAT plans were generated with Ergo++ (Elekta) using a 10MV single arc. Pareto fronts based on (i) different MLC block margin around PTV (ranging from +4mm to -2mm with 1 mm step) and (ii) different prescription isodose line (IDS) ranging from 50% to 100% of PD were produced. For each block margin, the greatest IDS fulfilling the two criteria: 95% of PTV volume reached 100% of PD and 90% of PTV reached 99% of PD was considered as that providing the optimal clinical plan for target coverage. The liver mean dose, V7Gy and V12Gy were used together with the PTV coverage (1-V100) to generate the fronts. The ratio of the prescription isodose surface volume to PTV volume (conformity index CI), gradient index (GI=V50/V100), the ratio of normal tissue volume receiving 50% of prescription dose and PTV volume (NTV50/PTV), homogeneity index (HI=D2%/PD) and healthy liver irradiation in terms of mean dose, V7Gy and V12Gy were calculated to compare different plans

Results: A total of about 450 plans (150 per lesion) were calculated for all block margins and isodose lines. Pareto fronts generated for one of the lesions are plotted in figure 1a,b. For all block margins, PTV coverage is deteriorated with the decrease of liver Dmean, V7Gy and V12Gy. The front for 1mm MLC margin is situated below and on the left of the other fronts for all the three different target sizes. Figure 1c,d show the GI plotted against the prescribed isodose lines and the HI index for the optimal clinical plans. In all cases GI shows a U-shaped behavior with minimum values at 1mm for all metrics. The location of these minimal points was found independent of tumor dimensions. Minimal GI values were found at HI values approximately equal to 1.3. Figure 1e and 1c show the CI and the NTV50/PTV versus HI. With 1mm MLC margin the optimal prescription isodose line was found 77-82% for the three different lesions.

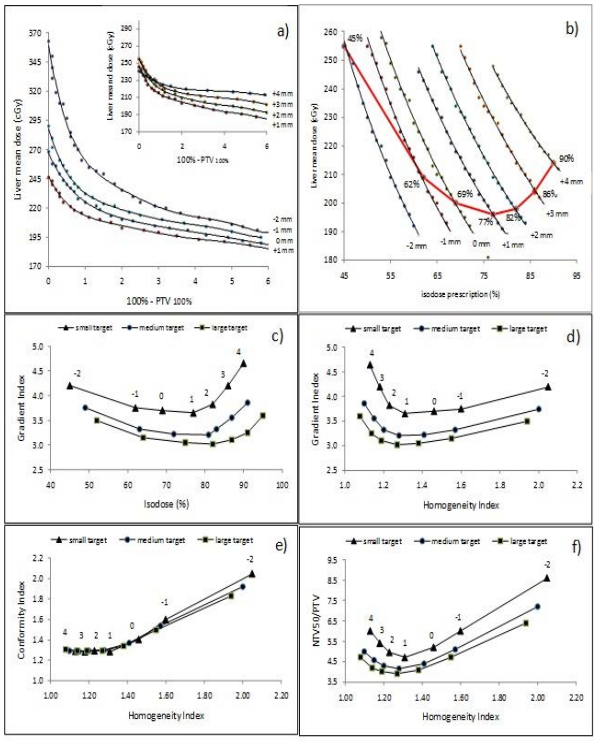

Figure 1: (a) Pareto fronts obtained for liver mean doses vs target coverage for all block margin. Each dot represents a single plan; (b) Pareto fronts obtained for liver mean dose and isodose lines prescriptions. Bold red line connects plans with same optimal dose coverage for different block margins (i.e. the clinical optimal plans obtained with the greatest IDS fulfilling the two criteria: 95% of PTV volume reached 100% of PD and 90% of PTV reached 99% of PD); (c) gradient index vs isodose line prescription for the clinical optimal plans, (d) gradient index vs homogeneity index for the clinical optimal plans, (e) conformity index vs homogeneity index for the clinical optimal plans, and (f) normal tissue volume receiving 50% of PD for the clinical optimal plans. In figure (c) to (f) numbers represent the block margins.

Conclusion: Pareto fronts provide a rigorous strategy to choice clinical optimal plans in SBRT treatments. Our evaluation shows that a 1mm MLC block margin provides the best results with regard healthy liver tissue irradiation and steepness of dose fallout. This choice provided optimal SBRT plans at dose prescription to 77%-82% isodose line for all target dimensions.

EP-1634

Treatment of extremity soft tissue sarcoma using protons - robustness of single and matching fields

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Purpose or Objective: Extremity soft tissue sarcomas (ESTS) are treated with combined surgery and radiotherapy, involving large volumes of healthy tissue. This increases late toxicity, which has a negative impact on quality of life. Due to the conformal dose distribution of protons a reduction of healthy tissue exposure can be expected. The clinical benefit in preventing long term toxicity can be fully exploited only if the reproducibility and stability of treatment delivery can be guaranteed. The aim of our study was to show the feasibility and robustness of actively scanned proton therapy with single and matched fields.

Material and Methods: In 8 postoperative ESTS patients CTV was defined as GTV radially expanded by 1.5cm and longitudinally by 4cm. For PTV the CTV was expanded isotropically by 1cm [1]. The dose prescription was 60Gy (RBE) to D50% of the PTV (2Gy (RBE)/fraction). For treatment planning the software Raystation v4.7 (Raysearch Laboratories, Sweden) was used. 4/8 patients with PTVs longer than 18cm (maximal available field length) required field matching. Robust optimization is the method of choice in Raystation when two fields with different isocenters are